

INTRODUCTION

P-excess from animal manure on soil balance¹

Stringent fertilization levels



Need for a sustainable resource management !



Increasing use of synthetic P-fertilizers

Phosphorus depletion²
Quality ↓ ↔ price ↑

RESEARCH QUESTION & METHODS

What is the potential of recycled bio-based fertilizers as substitute for synthetic P-fertilizers ?

Phosphorus fractionation
Struvite, FePO₄-sludge, TSP, pig manure, digestate



Solubility

H₂O < ammoniumcitrate (AC) < mineral acid (MA)

Soil analysis

- PAE: direct available, inorganic
- PAI: available in the longer term
- Pw: combination PAE & PAI
- Prhizon: direct available, (in)organic

$$PUE(\text{parameter})_{\text{substitute}} = \frac{\text{parameter}_{\text{substitute}} - \text{parameter}_{\text{control}}}{\text{parameter}_{\text{reference}} - \text{parameter}_{\text{control}}} \times 100$$

Pot experiment

Sand & Rheinsand, maize (n=4)



Plant reaction

- yield
- dry weight
- P-uptake

Phosphorus use efficiency

RESULTS & DISCUSSION

Solubility

	TSP	struvite	FePO ₄ sludge	digestate	pig manure
Total P (g kg ⁻¹ FW)	430 ± 5	294 ± 3	0.50 ± 0.02	2.9 ± 0.0	3.3 ± 0.0
P soluble in H ₂ O	96%	1.7%	4.0%	79%	85%
P soluble in AC	95%	96%	100%	93%	91%
P soluble in MA	93%	98%	92%	100%	97%

Struvite

- slow release, mixed nutrient fertilizer
- high P-availability in the beginning of the growing season
- stock for later release

FePO₄-sludge

- not interesting as start fertilizer
- potential to increase the capacity of P-deficient soils

Digestate vs. animal manure

- higher yield and P-uptake
- slower P-release => less leaching
- higher release of difficult available soil phosphate

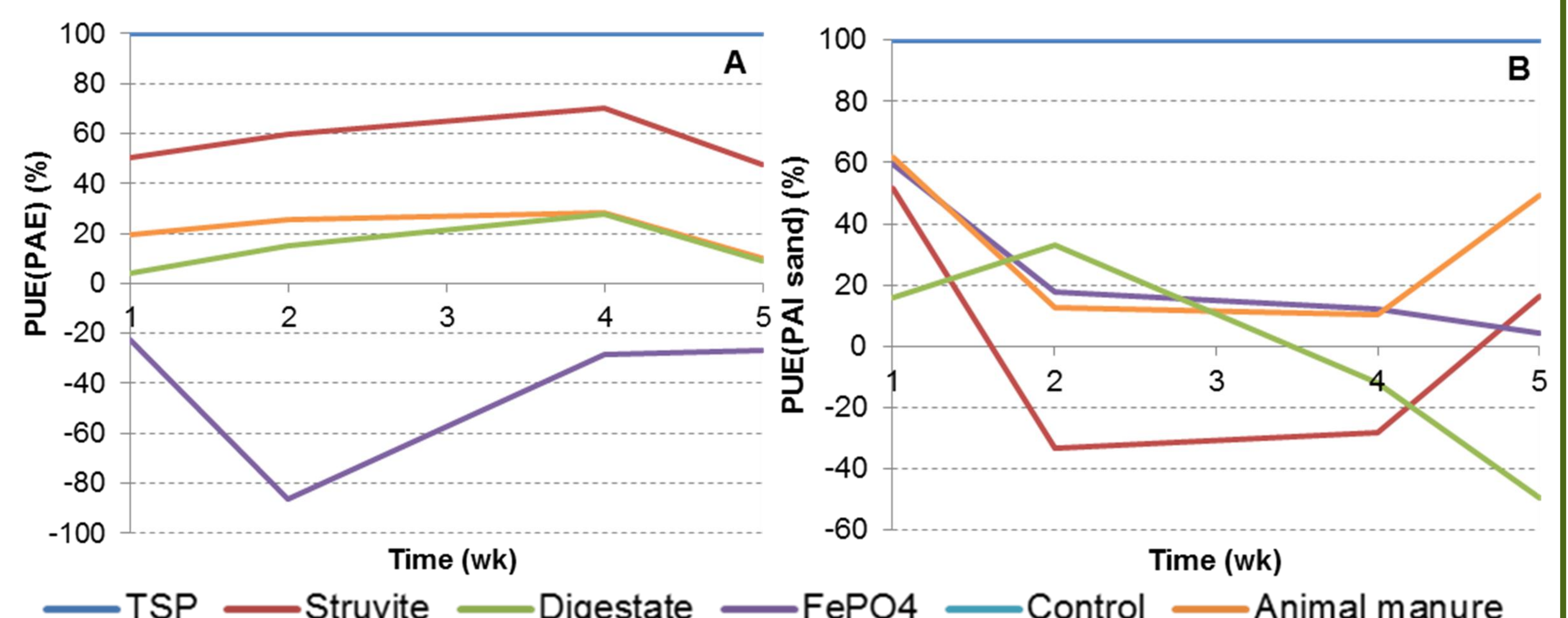


Phosphorus use efficiency

	PUE _{FW-yield} (%) Sand	PUE _{FW-yield} (%) Rheinsand	PUE _{DW-yield} (%) Sand	PUE _{DW-yield} (%) Rheinsand	PUE _{P-uptake} (%) Sand	PUE _{P-uptake} (%) Rheinsand
Struvite	-21 ^a	75	10 ^a	67	22	42
FePO ₄	-68 ^a	159	-16 ^a	233	16	3.3
Pig manure	-46 ^a	8.9	-8.5 ^a	-67 ^b	37	80
Digestate	-67 ^a	-45 ^b	-90 ^a	-100 ^b	80	63

	PUE _{PAE} Sand	PUE _{Pw} Sand	PUE _{PAI} Sand	PUE _{PAI} Rheinsand	PUE _{sol} Sand	PUE _{sol} Rheinsand
Struvite	57	374	1.6	-94 ^c	145	60
FePO ₄	-41 ^b	-46 ^b	23	-606 ^c	-131 ^b	3.2
Pig manure	21	24	34	-215 ^c	130	114
Digestate	14	212	-3.0	453 ^c	71	81

^a TSP < blank, ^b substitute < blank, ^c not significantly different with the control and TSP



CONCLUSIONS

- There is potential for use of bio-based waste streams as sustainable phosphorus fertilizers
- A better categorization of different green organic and inorganic fertilizers in European legislation is required
- A combination of the PAE-method and rhizon soil solution samplers is proposed to evaluate the direct available phosphorus

REFERENCES

- ¹ Schröder, J.J., Smit, A.L., Cordell, D., Rosemarin, A., 2011. Improved phosphorus use efficiency in agriculture: A key requirement for its sustainable use. *Chemosphere*. 84, 822-831.
- ² Neset, T.S., Cordell, D., 2012. Global phosphorus scarcity: identifying synergies for a sustainable future. *J. Sci. food agric.* 92, 2-6.